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ABSTRACT

The key question to ask in determining whether a solution will be found to the world food problem is whether people will learn to effectively manage the food/population balance. Predictions concerning the world food situation should be made on the basis of these factors: (1) possible future changes involving technological development, political and weather upheavals, and resource discoveries or depletions; (2) the evolving state of affairs in areas such as food indicators, demographic trends, behavioral relationships, and weather conditions; and (3) socially controllable changes such as resource allocations, social priorities, political intervention, and economic policy. Analytic models to describe and simulate world food problems can be based upon food systems or upon interacton among variables such as technology, natural catastrophies, and social and political trends. Analysis of the international food situation by either of these models leads to the conclusion that poor importing nations will improve their food conditions if they increase domestic food production rates, decrease their dependence on imported food, and enforce population control at the national level. The implication of this research for developed nations, and particularly for the United States as the world's largest surplus food producer, is that careful consideration should be given to the formation of appropriate national policies in the face of conflicting humanitarian, economic, and political considerations. (Author/DE)

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NEITHER FEAST NOR FAMINE

Summary of the Second Twenty Year Forecast Project

by

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F28

September 1977

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PREFACE

The study of the world food supply problem is the second in an on-going series of studies called the Twenty Year Forecast Project at the University of Southern California's Center for Futures Research. These studies are designed to provide early insight into the long-term social, economic and business consequences of change. Each annual phase concentrates on a major societal issue (e.g., energy, food, business/governmental relations, the world economic order), bringing together a multi-disciplinary team of scholars and researchers with representatives of the sponsor organizations to perform forecasts and analyses that can be used by planners and policy makers.

This work would not be possible without the continued support of our sponsors which, in the case of this study, included the following organizations:

ARA Food Services Company
Atlantic Richfield
Baskin Robbins
Dart Industries
Ford Motor Company
General Electric
Monsanto
National Science Foundation
Occidental Petroleum
Phillips Petroleum
Prudential Insurance Company of America
Sears, Roebuck and Company
Standard Oil Company
TRW
Union Carbide
Weyerhaeuser Company

Throughout the course of this research representatives of the sponsoring organizations, faculty and staff members of U.S.C., Delphi panelists, and participants in the intensive interactive analyses gave generously of their time and intellect. We never felt constrained by these contributions. Rather, we consider ourselves fortunate to have had such a rich milieu to draw upon. We tried hard to make this document worthy of their contributions. If it fails in any way, it is a reflection on our efforts and not on theirs.

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DELPHI INQUIRY

Eighteen Participants

INTERACTIVE MODELING WORK

Seventeen Participants in World Food Model Simulation Workshops

NEITHER FEAST NOR FAMINE

Summary Report

The food shortages of 1973 and 1974 brought the food/population balance to the foreground of world attention. World recognition of the criticality of this issue was long overdue. One of the potential benefits of this recognition was that political and intellectual leaders would devote a more substantial portion of their energy to resolving the issue. Indeed, world food was the focus of many political debates and intellectual analyses in the 1975-76 time period. The net result of these efforts was consensus as to the criticality of the food/population balance, the need for improved food production around the world, and the need for food reserves to protect all nations from the prospects of a crop failure.

In spite of the consensus, however, very little positive action has resulted from this increased awareness of the food situation. The bumper crop of 1976 and its expected encore in 1977 appear to have effectively defused the concerns which flourished in the World Food Conference in Rome in 1974. This is particularly disturbing since virtually all analytic research into world food prospects confirmed the long term criticality of the food/population balance and regarded the prospects for massive famines as quite high--notwithstanding the fact that bumper crops would occasionally occur.

The research reported herein was initiated in 1975 when the world food problem was receiving considerable international attention. Our concern was not that future alternatives had not been evaluated but rather that virtually all of the alternatives led to undesirable outcomes.

These alternatives all indicated that population growth was continuing without prospects for control; that much of the accessible fertile land was in the cultivation cycle; that food production growth in the future would require large capital investments; that new acreage would probably be less productive than current acreage; that in the poor nations of the world, urban-populations dependent upon low-cost food to avoid immediate starvation would continue to grow at alarming rates; and so on. The general view was that the poor world was involved in a grotesque race between people and food production. Largely as spectators, inhabitants of the wealthy world were warned that people seemed to be winning the race. Constrained to existing trends, extrapolative research came up with the right answers to the wrong question. Extrapolative projections only indicate the rate at which regional food deficits are increasing. The key question is not to determine when and where mass famines will take place, but rather to figure out how to make the image of a race inappropriate by more effective management of the food/population balance. If Malthus is not to prevail, what are the key alternatives and what are the consequences of these alternatives for both the poor and rich people of the world?

RESEARCH APPROACH

In an attempt to answer these questions, the Center for Futures Research (CFR) began a systematic study of the changing forces that are interacting to determine the future of the world food situation. The basic assumption of this research was that the future was not preordained by extrapolations of the past. Rather, the future would be determined

by the interaction of the three types of components shown in Figure 1.

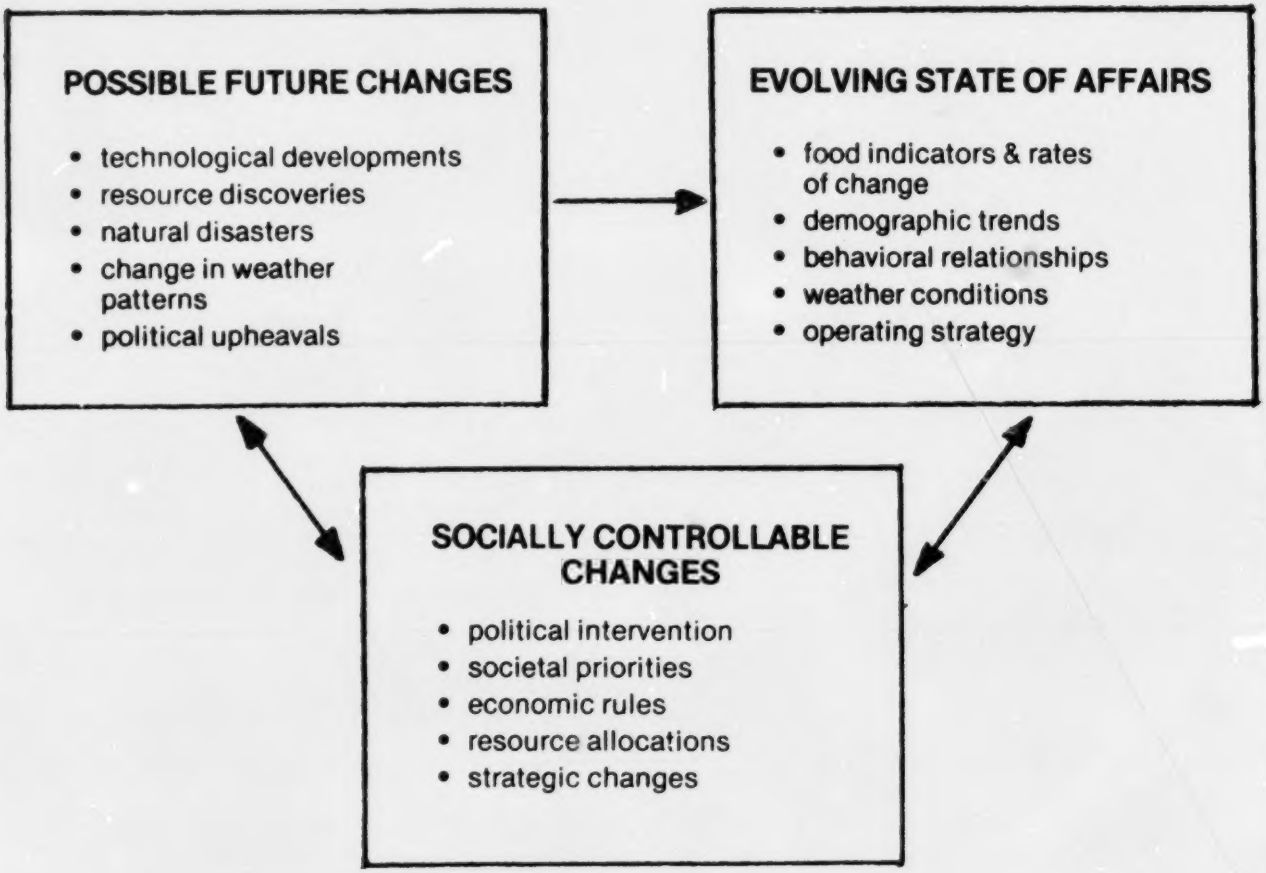
In embarking upon this research, it seemed that any methodology based totally on the extrapolation of the past would ultimately focus on "when the race would end" rather than the important question of "how its course might be diverted." Since the future invariably contains technical, political, social and resource changes that are never fully anticipated by historical trends, we believe that the future is not as constrained by the past as a totally historical model might suggest. Therefore, one of the principal tasks of this research was to create an analytic procedure that could be used to forecast alternative futures which reflected not just the constraints of historic trends, but alternatives created by future changes as well.

But what were these changes and how might they come about? Although the literature contained discussions of many technical, environmental and policy changes which might affect or even shape these futures, many other changes may not have been identified. It seemed important to develop a methodology that could help in identifying some of these changes, especially since the inclusion of these changes might reveal desirable evolutionary paths regarding world food.

Our approach to this problem was to design a creative exploration process necessary to anticipate possible future changes whose occurrence could reverse the worsening food/population trends, and to analyze the degree to which society could bring these changes about. The vehicle developed for this purpose is called interactive cross-impact analysis.

Figure 1

DETERMINANTS OF THE FUTURE



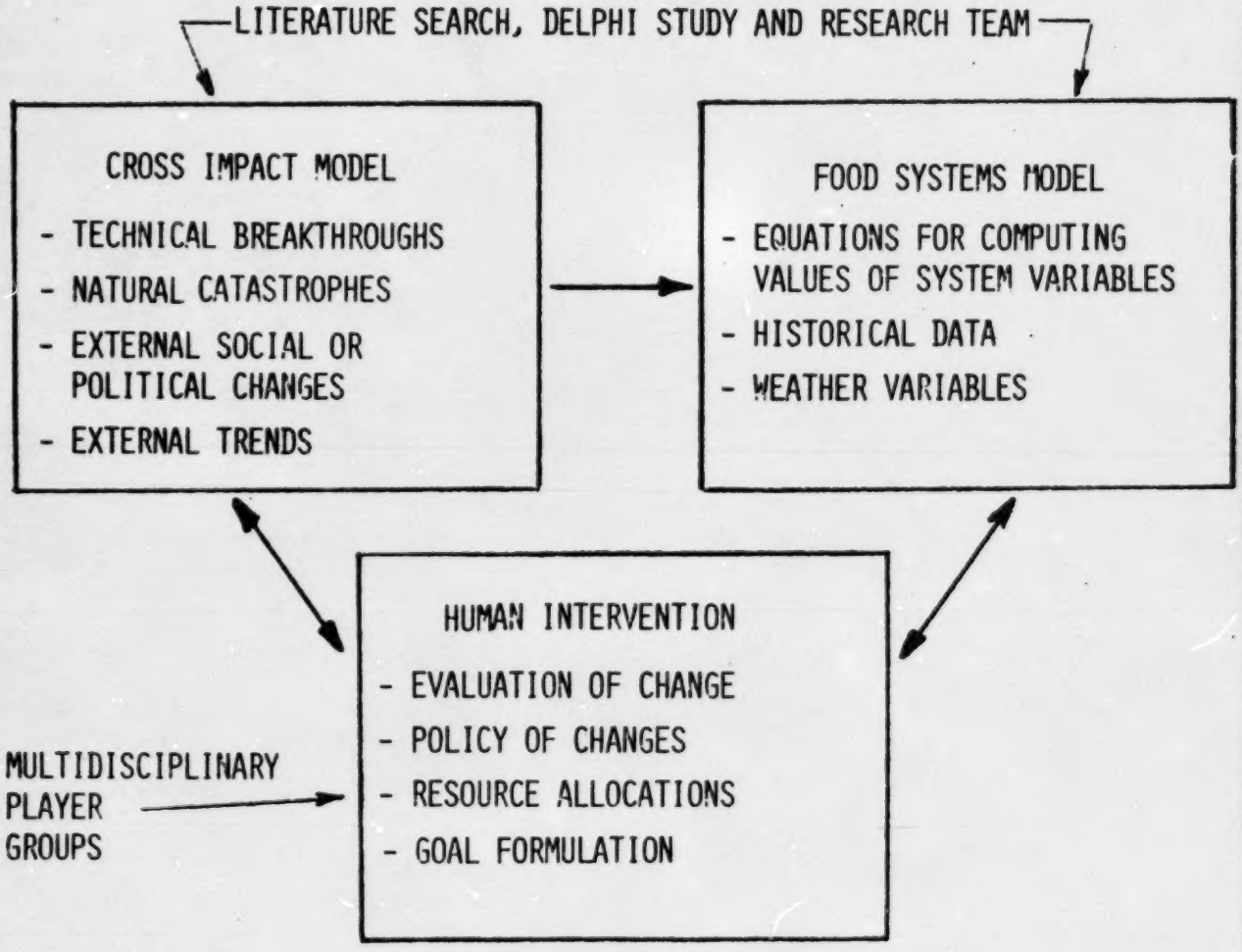
In such an analysis, the deliberations of people are combined with projections from simulation models to produce alternative future scenarios. The analytic simulation models describe the trends, and probabilistically describe the uncertain forces of weather, technical change, resource discoveries, outbreaks of agricultural blights, etc. These models simulate alternative futures using conventional techniques, except that they have been programmed to forecast only one year at a time. The results of each annual forecast are then presented to the people who are simulating societal decision makersbefore the analysis is continued.

In order to make these interactive analyses realistic, considerable analytic research had to be conducted. A food systems model had to be developed which faithfully described ongoing trends. Not only did this model have to be capable of projecting key food and population trends based on historical data and contingent societal policies, but it also had to be able to adjust its forecasts to reflect both the impact of the occurrence of future events and the new policies which interactive participants might wish to introduce. Forecasts of future developments in food production, storage and distribution had to be made, and the impacts of these developments on the food systems model had to be estimated. These data had to be integrated into a computer program that supported and facilitated the deliberations of the interactors.

The forecasting system that was produced described the elements of the change process in the manner shown in Figure 2. As can be seen, two analytic models were produced, a food systems model and a cross-impact

Figure 2

PROCESS OF CHANGE



model. The development of these models drew upon inputs from the literature, the research team, and from a Delphi study. The Delphi study was designed expressly for the purpose of exploring and quantifying scientific judgments regarding the key foreseeable changes that might affect world food conditions and the impacts of these changes on those conditions. This summary presents some of the forecasting data that was collected, the nominal futures these data suggest, the alternatives resulting from the interactive analysis conducted in this research, and a discussion of some of the impacts of these alternatives on American business and society.

BACKGROUND

What is the food problem? Figure 3 contains a series of statements that might represent differing opinions about the nature of the problem. Although each of these relates to some aspect of what has happened or is happening, very few are pure truth and none captures the totality of the food problem.

The conclusion drawn from our research is that the real issue is management--the management of a food/population balance in a world that includes a wide variety of technical, social, political and economic agendas. From this perspective, the statements in Figure 3 represent a series of criticisms or challenges to the manner in which food related activities are being or have been managed by society. The theme that pervades the remainder of this discussion of background issues is that societal management of food production and consumption has determined the nature of the food problem. The question addressed by the findings of

Figure 3

A SERIES OF POSSIBLE CONJECTURES CONCERNING THE BASIC NATURE OF THE WORLD FOOD PROBLEM

1. There is no shortage of food and none is likely within the next twenty years. The current situation simply involves too many poor people who cannot afford to pay for the food they would like to consume. If economic conditions could be improved, the farmers of the world would have no difficulty producing enough food to meet the demand.

2. The food problem is really a population problem. Food production is increasing steadily, but it cannot keep pace with population growth.

3. Food reserves are low because the rich nations gave their surpluses to the poor countries.

4. The Russians created the food problem with their grain deals.

5. OPEC caused the food problem by increasing the cost of energy.

6. The food problem is a transient phenomenon caused by several bad harvests which depleted U.S. grain reserves.

7. The food problem is a result of the domestic policies of less developed nations. By controlling food prices at unreasonably low levels, they have inhibited the use of additional resources and advanced technological methods that could increase their food production.

8. The affluent nations caused the food problem by over-consumption and by wasting enormous amounts of fertilizer, land, and water on lawns and golf courses.

9. The world food problem is a result of neglect of the domestic agricultural sector by many populous/poor nations. Had they invested a greater proportion of their wealth in agriculture rather than in tourist hotels and imported luxury items, there would be no shortage of food.

the study concerns the manner in which societal choices in this area could achieve "a better future."

In order to recognize a better future, it is necessary to define food goals. This research defined food goals in terms of two simple parameters:

- o the ability to provide an adequate quantity of food for all people (including the distribution mechanisms)
- o to provide protection from periodic shortages inherent in agricultural production

In this context, food problems ar[illegible]hen either or both of these goals are not being met.

ANALYTIC RESULTS

The analytic model described earlier can be used in three different ways: deterministic, probabilistic and interactive.

A. DETERMINISTIC PROJECTIONS

When the food model is run in a deterministic mode, the effects of all sources of uncertainty are eliminated. These sources of uncertainty are weather, technological and environmental developments, and policy interventions. Although weather fluctuations do have year-to-year effects on consumption, reserves and trade,that ultimately cause the results of deterministic runs to differ from the average of the probabilistic runs, deterministic runs are useful in studying the impact of policy choices such as production and consumption growth rates, trade arrangements and pre-specified contingency plans.

A large number of deterministic runs were completed. To emphasize the main points that emerged from the analysis, the consequences of two sets of regional production growth and consumption growth policies are discussed. The production growth alternatives are termed "historic" and "optimistic." Historic production growth is simply an extrapolation of regional trends over the last 15 years. Optimistic production growth rates were estimated by the Delphi panel as the maximum growth rates that can practically be sustained over 20 years if major commitments to increasing agricultural production are made.

Figure 4 projects per capita grain production for three types of regions: poor importers (the Third World), rich importers (West Europe, East Europe, Japan and the Middle East), and exporters (North America and Australia).*

The projections in Figure 4 lead to three important conclusions:

1) It is possible to maintain a steady increase in per capita production in all regions if historic patterns of population and food production growth can be maintained.

2) An increase from historic to optimistic rates of production growth by the importers results in only a small improvement in per capita productivity. This reflects the fact that recent historic production growth rates have been very high and are close to the maximum sustainable rates estimated by the Delphi panel.

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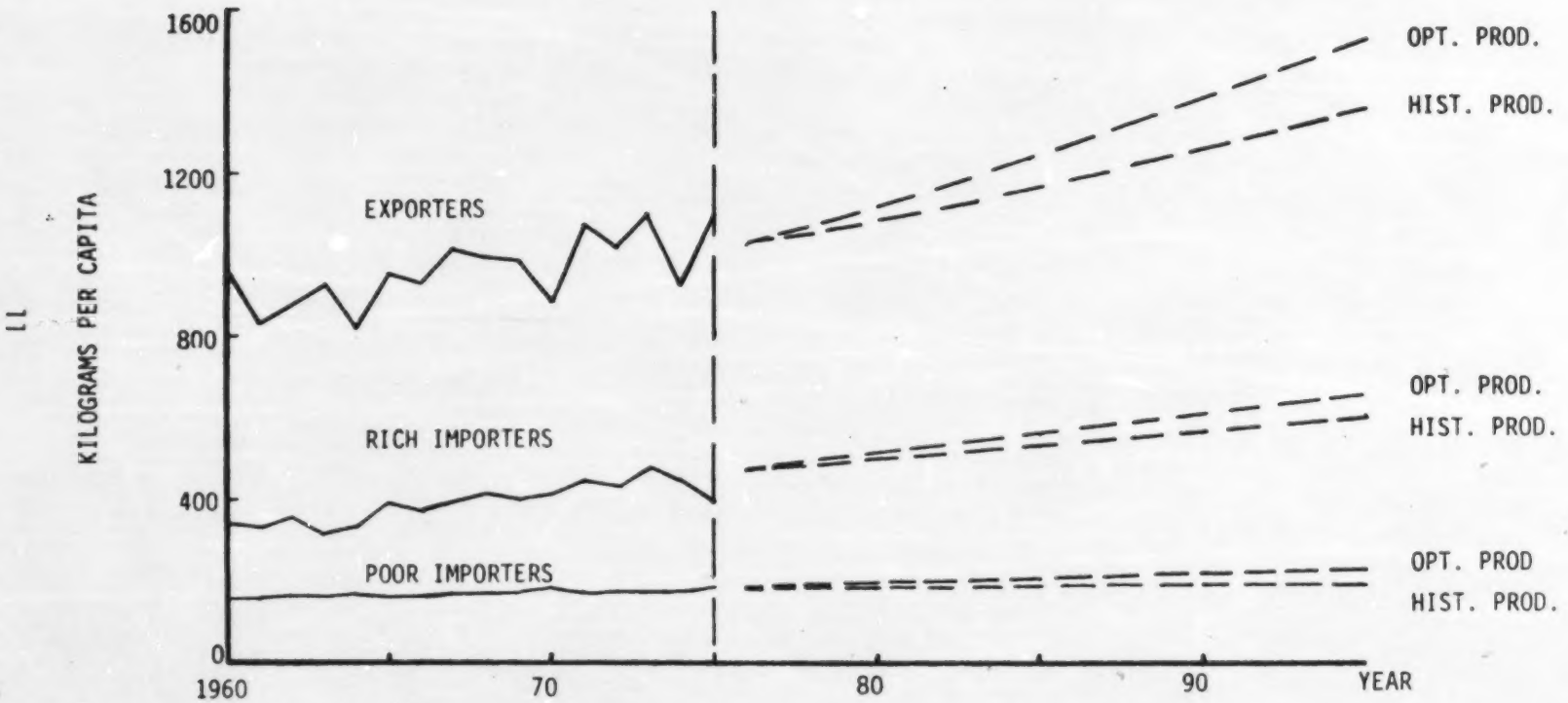
*For this research project the world was divided into ten regions which are almost identical to the ones used by Mesarovic and Pestel in Mankind At The Turning Point (1974).

Figure 4

PER CAPITA GRAIN PROD.



3) Although the absolute rate of production growth increases faster for the poor importers than for the rich importers,* poor importers obtain smaller per capita gains as a result of their greater population growth.

a. Feasibility of the Production Growth Alternatives

Maintaining historic production growth trends will be more difficult in the next two decades than it was in the past. All of the easily accessible fertile land is now in production. Additional land will either be of poorer quality or will require extensive investment (clearing forests, draining swamps, developing irrigation, etc.) Such development cannot practically be accomplished at a rate comparable to that at which land was added to the cultivation cycle in the past, even if cost were not an overwhelming problem. Thus, if historic food production growth rates are to be maintained or exceeded, the increases will have to come largely from increases in per acre yield.

Current constraints on yield increases are not nearly as binding as the constraints posed by the limited amount of high quality farm land. Continued yield increases are within the current state of the art even for the high yield producers. The issue is not one of feasibility but of political choice, priorities, economics and technology transfer. The

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*When each group follows optimistic production patterns, absolute production is increasing by a compound growth rate of 2.9%/year for the rich importers and 3.5%/year for the poor importers.

growth in production realized in the poor regions in the past decade was in large part stimulated by the green revolution. The diffusion of this technology appears to have slowed down. Whether or not this thrust will be picked up by the poor nations in the future is uncertain. Very few poor nations have as yet placed a high priority on food production. Also, the double bind caused by recent inflation in fertilizer and international food prices makes the outlook for sustained productivity improvements bleak for the poor regions.

b. Impact on Trade

Although the range of improvement in per capita productivity in Figure 4 appears to be small, it has an enormous impact on the amount of grain traded on the international market if stable consumption trends are to be maintained. Figure 5 presents projections of the quantity of grain traded on the world market (assuming historic per capita consumption growth trends are maintained) with the two productions growth trends presented in Figure 4.

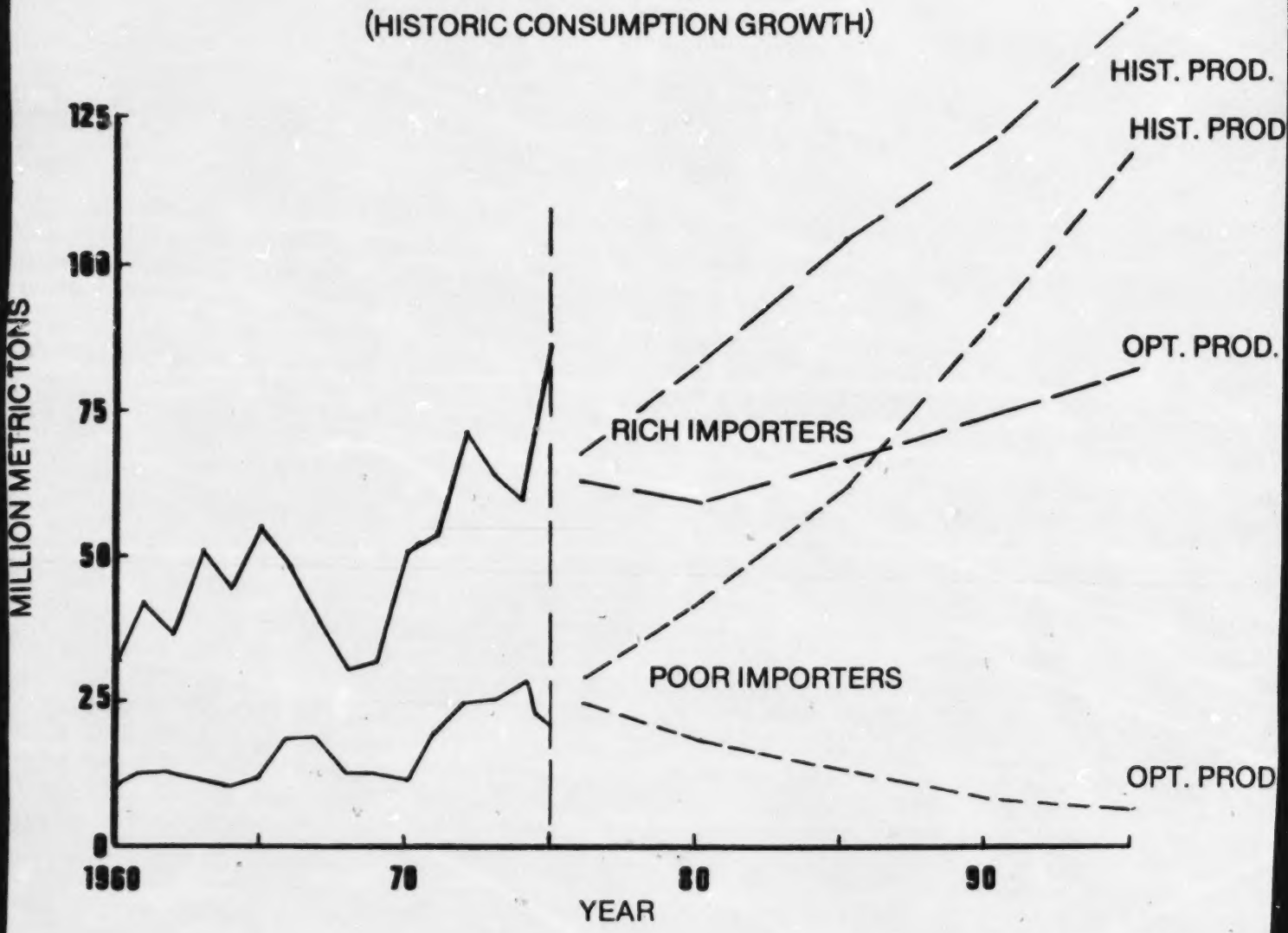
If the importers maintain historic domestic production growth rates, grain imports increase dramatically--particularly in the poor regions. This scenario is highly unlikely, not only because weather and other change variables are held constant, but because the poor importers could not possibly afford such food imports (47% of world imports).

On the other hand, if the importing regions could achieve the optimistic growth rates in their domestic production, a far more realistic situation obtains on the international grain market. With just the modest per capita

Figure 5

GRAIN IMPORTS

(HISTORIC CONSUMPTION GROWTH)



production gains shown in Figure 4, the poor importers are able to reduce their import demands considerabley. By the mid 1990's they are almost self-sufficient in food. Quite to the contrary, the rich importers continue to increase their demand for grain on the international market.

B. PROBABILISTIC PROJECTIONS

Coupling the probabilistic components--weather variables and the possible future events in the cross-impact model--to the food systems model provides additional insights that are not available from the deterministic analyses. When run probabilistically, actual grain production does not necessarily equal planned production. On the contrary, actual production is almost always somewhat higher or lower than target. This variability creates the need for food reserves. In the deterministic runs, reserves are irrelevant, since production always equals target. Furthermore, the fact that production is variable means that the model must contain a set of operational guidelines (representing regional policies) which it can use to decide what course of action to follow for each combination of outcomes that may occur. These guidelines are used to determine actual regional consumption levels and subsequent food production targets based on computed production (regional and world), regional consumption, regional reserves, regional wealth, etc.* Finally the

*For example in the deterministic runs, planned imports always equalled actual imports and the cost of these imports are always the same as budgeted costs. When the model is run probabilistically, planned levels do not equal actuals. Hence, it is possible for an importing region to exceed its production target while the world in general has had enough bad weather that the price of food on the world market is higher than expected. Under this combination of circumstances the hypothetical importer may purchase less food than its original import target, but still spend more due to the increased price of food.

uncertainty inherent in the potential occurrence of technical developments and changes in environmental conditions adds another level of richness and complexity. Some of the more important forecasts of these developments by the Delphi panel are presented in Figure 6.

Figures 7 and 8 present a "typical" scenario* generated by the combination of the food systems model (with the weather variable operating probabilistically in each of the ten regions) and the cross-impact model. This scenario assumes that historic production and consumption trends are being maintained. As can be seen, year-to-year variations are substantial.

The typical scenario contains periods of high and low production by the importers, with corresponding periods of low and high demand for grain in the world markets. The ability to follow the production and consumption trend projections obtained in the deterministic analyses depends upon regional maintenance of agricultural policies that are consistent with the long-term goal of steady expansion in consumption. Such policies include two components: 1) continual expansion of production even during periods of surplus (bountiful weather), and 2) storage of excess food production to cover periods of shortfall (as opposed to retiring acreage and over consuming during periods of surplus).

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*These variations may lead one to question whether this particular scenario is really "typical" given the probability distribution of the regional weather variables and the events. In the scenarios presented in Figures 7 and 8 regional weather patterns did not exhibit any extreme sequences of abnormally good or bad weather. Similarly, the mix of events which occurred was not abnormally favorable nor unfavorable to agricultural production. The scenario presented in these figures appears quite similar to most of the others generated by the model in that the policies and problems it suggests are repeated in many runs.

Figure 6

SELECTED FORECASTS OF THE DELPHI PANEL

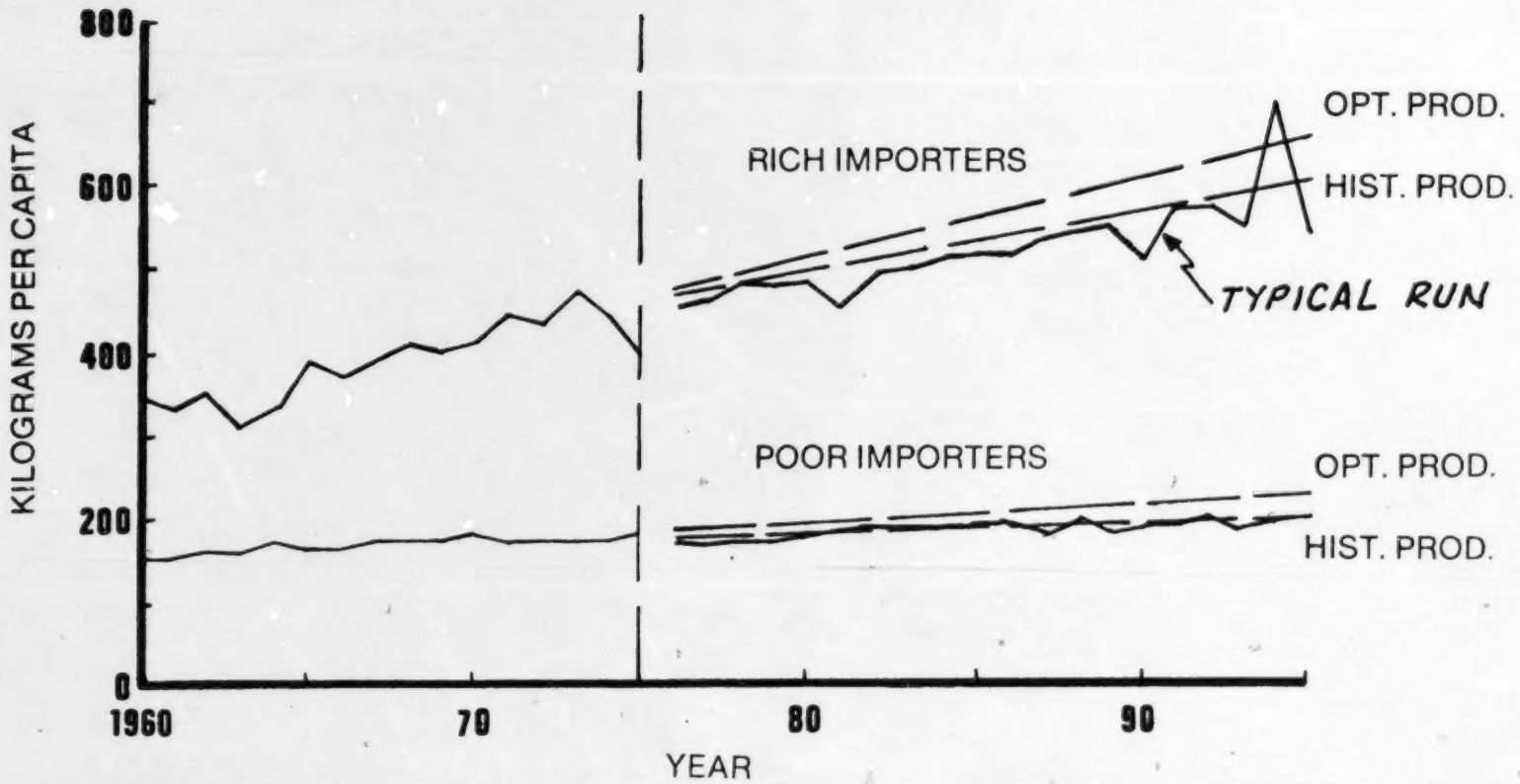
	Developments	Probability of Occurrence by 1996	Repeatable Events*
1.	Nitrogen fixing grains are developed which reduce the need for nitrogenous fertilizer by 10%.	.40	
2.	Widespread grain disease occurs--15% of the crop in the affected area is lost.		.02/reg/yr**
3.	Genetic breakthrough occurs which allows the average yield of non-irrigated grains to increase by 25%.		.05/yr
4.	Development of improved grain storage techniques which reduce potential losses by 10%.		.02/yr
5.	Breakthroughs in Integrated Pest Control techniques which lead to 25% reduction in crop production losses in areas where it is applied.		.02/yr
6.	The beefalo is successfully raised and marketed.	.50	
7.	Development of beef twinning techniques that lead to an increase in the average calving rate of 30%.	.70	
8.	Development of a forage grass which will grow in arid areas with 50% of normal water requirements; thus allowing these areas to support twice as many cattle as currently.	.30	
9.	Breakthrough in "unconventional" feed production makes it commercially feasible to permit a 10+% reduction in the amount of grain consumed by livestock.		.04/yr
10.	Simple and inexpensive solar cookers are developed and utilized by significant numbers of peasant families.	.15	

*These events may occur more than once in the next two decades. The values shown are their probabilities of occuring in any single year.

**These events are also repeatable, but only affect one of the ten regions when they occur. The values shown are their probabilities of occurring in any region in any year.

Figure 7

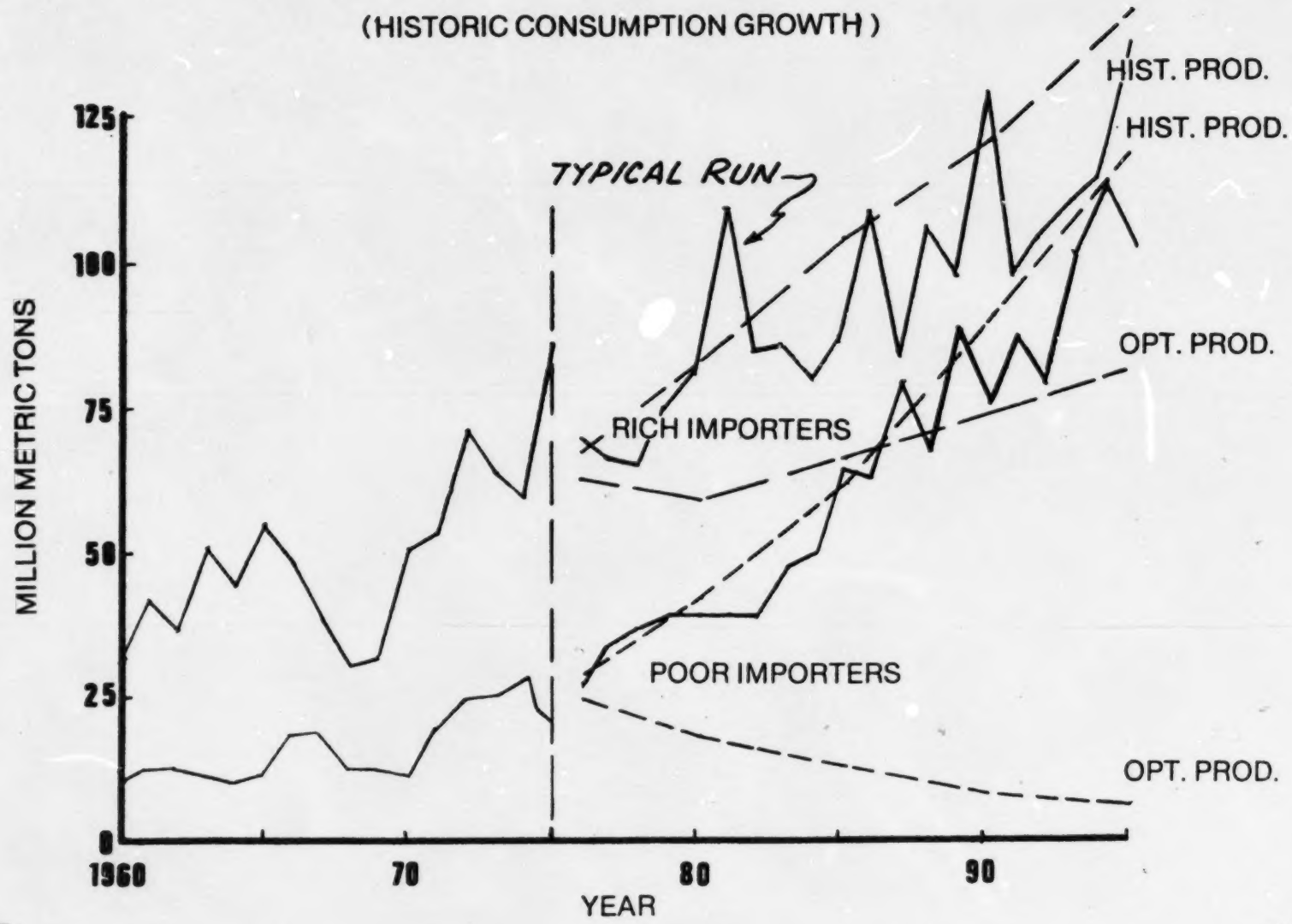
PER CAPITA GRAIN PROD.



Source: Calculated from data in U.S.D.A., F.A.S., Reference Tables on Wheat, Corn and Coarse Grains and Rice," and
Projections computed from Center for Futures Research world food model.

Figure 8

GRAIN IMPORTS WITH PROBABILISTIC WEATHER



The production uncertainties produced by weather fluctuations, pests, etc. pose a more serious threat to the poor regions than they pose to the rich regions. Because of extremely low levels of per capita consumption, failure to meet food supply targets means reduced consumption levels and ultimately starvation.* Consequently, when a poor region is confronted with a cyclic food shortage that it cannot cover from its reserve stocks, the acquisition of additional food from international sources becomes an urgent problem. If the region cannot obtain food aid or credit, it must divert scarce foreign exchange from productive investment projects to cover food imports. In such cases, the immediate pressures of short-run survival take precedence over long-run development goals. Viewed from this perspective, a poor region which must periodically rely on others to maintain food consumption is in a one-sided dependency relationship with the exporters. To the food exporters, a poor region confronted with a food shortfall is an unwelcomed customer during periods of "tight" supply.

C. INTERACTIVE ANALYSIS

Interactive analyses use the probabilistic model in conjunction with a group of people who act as regional decision makers and attempt to guide the food conditions in each of the regions and for the world. The probabilistic models are used in the single scenario mode; i.e., the model pauses after each simulated year. It reports results for that year, indicates the nominal targets for the coming year (assuming no change in strategy), and awaits inputs from the interactors.

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* Neither the possibility of such short falls nor their potential magnitudes are obtainable from the deterministic analyses.

The interactors evaluate the interim results to develop a more complete sense of the food conditons in each region than is contained in the quantitative food data. They also discuss the consequences--political, social, and economic--that they think are likely to accompany these conditions.* After completing their deliberations on the state of food conditions, a policy analysis is conducted. As a result of this analysis, the interactors may change any component of their regional food policy--their production or consumption targets, their domestic research and development programs, etc. They may also negotiate with representatives of other regions for long-term food purchases, aid, or the establishment of international (world) food programs. The changes they decide upon are then used to modify the policies included in the analytic models before the next year is simulated. At their option, the model can project more than one year at a time without reporting back to them.

Performing a probabilistic analysis in an interactive mode greatly increases the degree of flexibility and reality that can be built into each simulation. Consider for example the different behavior of the U.S. in response to the Indian food shortages in 1966-67 and in 1972. At the onset of the Indian drought of 1966-67 the U.S. had large grain reserves

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*To aid in these deliberations all of the data projected by the model is available to them. This includes the current status of each cross-impact event and trend, as well as a time series of all previous values calculated by the food systems model. For example, if the simulation has just completed projecting 1985 they may request a region by region print-out of production growth trends for all of the years from 1975-1985. They may also ask for the amount of foreign exchange used for food purchases, the levels of food reserves, population growth, etc.

and the international price of wheat was only $60 per ton. The "opportunity cost" to the U.S. of shipping 20 million metric tons of wheat as food aid to India was low. Whereas, during India's monsoon failure in 1972, most exportable stocks had been tied up by the Soviet Union. In this situation, the U.S. could not make food aid available without either reducing domestic grain consumption or abrogating other long-term commitments. Most of the policy changes that enter into regional food decisions (such as those which influenced U.S. policy toward India) are captured in an interactive analysis.

The flexibility acquired by introducing regional decision makers into the analytic modeling structure makes it possible to anticipate future contingencies and policy developments. This can not be done as successfully by more conventional modeling techniques which replace societal decision makers with "built-in" sets of contingent policy guidelines. The shortcoming of conventional approaches is that it is impossible to develop a "complete" set of contingent policy guidelines. There are two reasons for this. First, if the contingent guidelines are solely based on historical policy behavior, they will be inadequate determinants of future policy. Second, even if the model builders include all of the non-historically based policy guidelines which they think may occur in the future, they may not have included many choices that decision makers will "invent" when faced with particular situations in the future. That is, new contingencies may arise which require different types of policy responses than those reflected in history or anticipated by the model builders.

CONCLUSIONS

1. Change in Trends

World food conditions in the next twenty years are not likely to follow the trends seen in the past two decades. The rising level of food imports by the poor regions will not be sustained. Food conditions will worsen for the poor importing nations unless they readjust their priorities to increase domestic food production growth rates and to reverse the trend toward increased dependency on imported food. This is not to say that these (poor importing) regions have not been expanding domestic food production in the past--they have been expanding production rapidly. However, this production expansion has barely outpaced the rapid population growth in many of these regions. Consequently, per capita food consumption has advanced at only modest rates. Furthermore, in the recent past an increasing portion of the food consumption growth in these regions has come from food imports. For instance, food imports for South Asia have risen from 5-6% in 1960 to 8-9% of their total consumption by 1975. At 1975 population levels, this meant that approximately 100 million South Asians relied on imported food to sustain a near subsistance level of food consumption. An extrapolation of historic production and consumption trends to 1985 show that their level of import dependency will double to 17-18%. It is questionable as to whether or not a poor region such as South Asia will be able to afford this level of imports. Although the exporting regions have the growth potential to meet continuing global growth in import demand, they will not produce this quantity of food unless they expect profitable commercial markets to exist. How can the poor nations of the world be viewed as commercial markets for massive food imports? How can the poor nations offset their growing food deficits?

2. Self-Help by the Poor

The obvious conclusion is that the poor nations cannot afford to finance large food deficits. Therefore, if food consumption trends in the poor nations of the world are to be sustained, these nations must increase domestic production growth rates above and beyond their already high historic rates and must control their populations to end spiraling growth in food consumption.

3. Self-Reliance in Food

Nothing that the affluent regions (both exporters and importers) can do unilaterally will improve food conditions in the poor/populous nations. First and foremost, the poor importers must recognize that their highest priority goal must be to achieve self-reliance in food. That is, they must achieve a condition whereby they can either produce or purchase the amount of food they plan to consume, without relying on massive food-aid programs from surplus producers.* They must be ready to take whatever steps are necessary to accomplish that end. If the poor importers adopt the goal of self-reliance in food, then there is a great deal that the affluent world can do to help them achieve that goal. The affluent nations can provide the technology, the long-term and short-term capital required to accelerate agricultural development, the educational programs, etc.

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*It should be noted that self-reliance as used here is not a utopian state of affairs. "Planned" consumption levels imply "acceptable," not necessarily "desirable" levels.

4. Diffusion of Existing Technology

The road will not be an easy one. There are no miraculous technological developments on the horizon which will dramatically reverse current food trends. On the contrary, much of the advanced technology that can be effectively used already exists. The problem involves such practical issues as quickly tailoring existing knowledge and technology for use in the labor abundant, capital scarce tropical countries of the world, the establishment of institutions and incentive structures that will motivate the rapid adoption of this technology, etc. In short, these are not the usual kinds of scientific problems that the modern world has been solving (or even thinking about) over the past century. Hence, the difficulties will be great for both the affluent and the poor nations.

5. Food Trade Growth--Less than Extrapolations Suggest

As a result of current trends it is likely that food production areas and population centers will be increasingly separated in the future. Consequently, international food trade will grow. However, since trade will be increasingly concentrated among affluent nations, current trade projections, which include large imports by the poor nations, will not be realized.

6. Self-Sufficiency and Self-Reliance

This research does not suggest that self-sufficiency in basic foodstuffs is either necessary or desirable for all nations. Rather, it suggests that self-reliance in food is essential for a stable form of interdependence to be developed among members of the world community. Food self-reliance is the ability of a nation to produce or purchase the food it plans to consume. When self-reliant nations enter into an interdependent relationship--even for an essential commodity such as food--both importers and exporters are self-motivated to fulfill their commitments. Since the poor importers have little to offer in trade, for them self-reliance equates to self-sufficiency.

7. Continuing Challenges in a Self-Reliant World

Even in a self-reliant world, the future contains many problems regarding food production. Driven by population and affluence, food consumption will continue to increase. Technological progress and investment in production increases will continue to be important. Food prices will continue to increase as less productive land is put into production and as the costs of agricultural inputs increase. Reserves will become increasingly important for offsetting periodic production shortfalls. The threat of diseases which can destroy crops throughout an entire region will increase as fewer types of new hybrid grains are cultivated. Thus, even if self-reliance is attained, proper management of the worldfood situation will remain a major challenge.

8. Population Control

Clearly, there is no long-term solution to the world food problem that does not include population control. World population simply cannot grow indefinitely in a finite world. Even if population control becomes accepted as a world goal, it does not become operationally viable until it is adopted and enforced at the national level. The goal of self-reliance in food requires population to be limited to a level that is domestically affordable. In the poor, populous nations this implies population control. Without the adoption of self-reliance in food at the national level, population control is likely to remain a goal without a policy maker. It is only through the adoption of self-reliance as a national goal that population control is likely to gain any political importance. In short, if a nation can only afford to have a population it can feed--either through food production or purchases--the goal of self-reliance contains a population control goal which takes on national political significance.

9. Self-Reliance--the Only Stable Future

An important conclusion of this research is that there are no alternative futures that do not move toward national self-reliance in food as an end condition. There are, however, many paths which may be taken in achieving self-reliance. These include a balance of growth in

food production and commerce such as has been achieved in Taiwan, as well as the isolationist self-survival path adopted by the People's Republic of China. Both of these nations are self-reliant or are moving toward self-reliance in food. Both are also moving toward long-term population control. The issues facing the world and the individual nations of the world are the willingness to accept the importance of self-reliance and the choice of the path to follow in reaching self-reliance.

10. Impacts on American Business and Society

The impacts of future world food conditions on the U.S. are numerous and varied. As the world's largest surplus food producer, the U.S.will be torn between conflicting humanitarian, economic and political considerations in a search for appropriate national policies. Problems of this type are of course, not new to the U.S. What is different with food is that the U.S. has only indirect control over the course of events surrrounding food conditions.

As a surplus food producer the U.S. is dependent upon the food import policies adopted by its customers. These policies determine the demand for food imports and hence the rate at which U.S. productive capacity should be expanded. Food productive capacities involve long-term investments which can only be justified on the basis of stable long-term markets. Long-term international purchase agreements tend to be quite fragile, particularly in periods of high economic turbulence. When

domestic surpluses exceed international demands, the U.S. faces acute domestic problems concerning farm income supports, storage (or disposal) of surplus food, etc.

Reinforcing these political uncertainties are basic uncertainties inherent in agricultural production. Notwithstanding modern technological improvements, weather and pests still cause vast fluctuations between production targets and actual outputs. These fluctuations exacerbate the fragility of long-term international food purchase agreements. Short-term economic realities make it difficult for a food importer to justify high priced food imports at a time when domestic harvests have been bountiful. Yet such purchases are essential in order to provide a basis for a steady expansion of U.S. production capacity.

a. Food Reserves

One development which can alleviate this condition is the establishment of a large food reserve. A large food reserve can be of immense value to the U.S. as well as to the world. For the U.S. it would stabilize demand and for the world it would provide much needed protection against periodic shortages. Reserves have traditionally been a domestic response to the problem of balancing fluctuations in food production with stable consumption demands. But even domestic reserves create complex political problems. Consumers invariably want food prices to drop during periods

of abundance. The farmers seek the opposite. Fortunately, the U.S. government has had the authority and the perspective to see that in the long-run both the food producers and consumers benefit from stability. As a result, the U.S. has maintained a policy that attempted to keep supply (productive capacity) in balance with demand by a combination of farm price supports, reserves and idled crop-land. However, as the share of U.S. food production earmarked for export markets grows the domestic tradeoffs which guided U.S. farm policy are no longer adequate.

It is important to note that the need for food reserves is strictly a result of fluctuations in food production and an unwillingness to accept corresponding fluctuations in consumption. The amount of food that should be held in reserve therefore depends upon the magnitude of the production deviations that can be expected and the degree to which consumption is permitted to vary. The proper size of a food reserve for protecting domestic U.S. consumption is smaller than one which would be needed if the U.S. reserves were also to protect importing nations from their production fluctuations. A world food reserve would have to be correspondingly larger. The issue of who should be responsible for the maintenance and cost of a world food reserve is far from resolved.

The most frequently mentioned obstacle to the establishment of food reserves is their cost. This preoccupation with cost stems from America's historical experience of accumulating reserves as an unwanted side effect of farm price support programs. However, currently (and for the foreseeable future) the U.S. is exporting about 35% of its annual grain production. The foreign exchange earnings resulting from these exports are very important

to the U.S. balance of payments, hence food reserve policies should be examined from a broader perspective than the recent past in which operating costs were of overriding concern. In the current environment it is important for America to use reserve policies to accomplish a broad range of goals, including the following: protect its export markets by guaranteeing reliability of supply, protect its farmers' income from short-term shifts (i.e., weather-induced shifts) in foreign demand, and protect the welfare of its consumers from unstable prices and supplies. These considerations appear to have been overlooked in the development of current U.S. reserve policy.

In the 1977-78 crop year, the U.S. plans to reduce its wheat production by 20% by idling eleven million acres. The object of this policy is to slow down production growth until demand increases while avoiding the creation of large U.S. government reserves. To offset the loss of income that would otherwise occur, farmers who participate in this program will be able to take advantage of a 20% increase in the wheat support price. The consequences of this policy are numerous. The immediate effect will be an increase in grain prices in the U.S. One of the indirect impacts of this policy will be to incentivize farmers to increase the wheat yield from their productive acreage to take advantage of the higher support prices. High U.S. grain prices will also incentivize foreign grain exporting nations--e.g., Argentina, South Africa, Australia, etc.--to expand their production since they will not have to compete with low-priced U.S. grain. If 1978 turns out to be a good year for food production these nations will erode the U.S. share of the international grain market to some extent, and U.S. reserves will increase. This could result in a

further reduction in U.S. production targets in 1979. If 1978 produces a bad harvest, world food conditions can again become critical, the threat of famine in many regions may become immediate, and the U.S. may not be able to mount a timely response to these conditions.

Regardless of whether adverse harvests occur in 1978 or 1979, they will occur eventually, and when they do, inadequate reserves and idled land will guarantee food shortages in the future. These shortages will trigger critical situations in various parts of the world which will have negative consequences for all.

A positive approach to the use of food reserves can not only avoid these negative conditions, but can also be used to stabilize U.S. food production growth to levels that are consistent with national interests. This occurs because, in addition to affecting world food prices, U.S. reserve policies also affect the size and distribution of food production growth rates. To the extent that the U.S. wants to maintain constant food production growth rates, a large food reserve can provide the needed clout. The cost of such reserves is a moot question since these costs would be borne by the consumers regardless of who holds the reserve. Since the U.S. is the only nation capable of building a reserve large enough to satisfy the multi-faceted criteria dictated by world needs, and since it is in the national interes to have such a reserve, U.S. policy toward food reserves should be re-evaluated.

b. U.S. Economic Conditions

Agricultural exports have become an important component of U.S. trade

in recent years. U.S. grain exports have largely offset growing U.S. oil imports, thereby protecting the purchasing power of the dollar and limiting inflation. Because of the cyclic nature of agricultural exports however, they can not be counted on to regularly offset oil imports. Thus, it is important for the U.S. to stabilize its agricultural exports with long-term sales agreements with importers and/or be able to maintain a substantial fraction of its surplus production in a reserve. This would reduce economic disruptions caused by frequent and large swings in the U.S. balance of trade.

Any increase in priority of U.S. agricultural exports may conflict with a move toward self-reliance in food among the third world nations. In an effort to become more self-sufficient in food, these nations will seek aid from the U.S. These requests will emphasize production technology and education as opposed to food for immediate consumption. This situation may pose a conflict in priorities to U.S. agricultural interests. If the U.S. is trying to maximize food export sales, it may appear that such technology transfers act against American self-interests. U.S. policy must avoid this trap. Improvement of food production in poor third world nations would not affect food sales, since these nations can not afford to pay for their food needs. If they become self-reliant, they may need less imported food, but they will be able to pay for their food purchases.

c. U.S. Human Rights Policy

In the pursuit of self-reliance many third world governments will have to impose harsh measures concerning freedom of choice as to procreation, purchases of non-essential goods, demographic mobility, land-use patterns, etc. Such measures invariably compromise human rights. Viewed from a purist perspective these measures will appear to conflict with U.S. policies which deny aid to nations which violate the human rights of their citizenry. What could be more inhumane than denying aid to poor/populous nations on the grounds that measures essential to their survival violate the human rights of their citizens?

However, since every tyrannical dictator will claim that his repressive measures are necessary in the pursuit of national survival, U.S. policy makers will not find it easy to decide which nations warrant U.S. aid and which do not. Nevertheless, the food population imbalances of the last few generations will not be tolerated for the next few generations. If the world does not take firm action to bring food and population into balance, Malthus will do it from the grave. Even this, however, does not herald the end of the world, it is just another path to self-reliance. One way or another, the nations of the world will become self-reliant--the choice of how this occurs belongs to all of us.